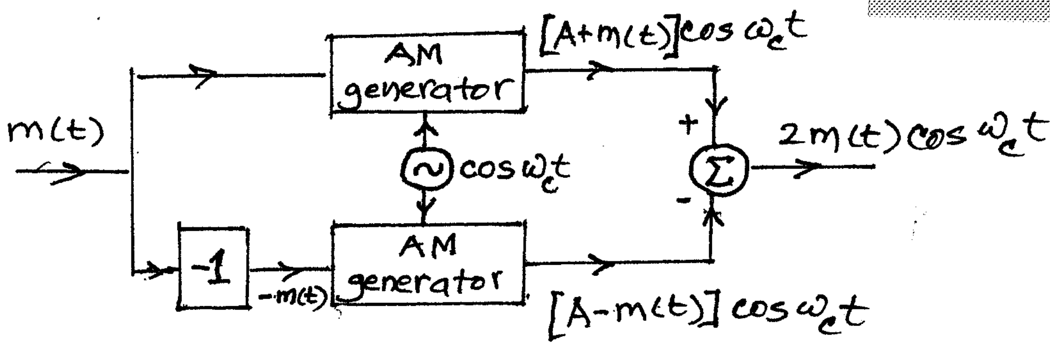

Fig. S4.3-5

4.3-5 When an input to a DSB-Sc generator is $m(t)$, the corresponding output is $m(t)\cos\omega_c t$. Clearly, if the input is $A + m(t)$, the corresponding output will be $[A + m(t)]\cos\omega_c t$. This is precisely the AM signal. Thus, by adding a dc of value A to the baseband signal $m(t)$, we can generate AM signal using a DSB-SC generator.
The converse is generally not true. However, we can generate DSB-SC using AM generators if we use two identical AM generators in a balanced scheme shown in Fig. S4.3-5 to cancel out the carrier component.

4.3-6 When an input to a DSB-SC demodulator is $m(t)\cos\omega_c t$, the corresponding output is $m(t)$. Clearly, if the input is $[A + m(t)]\cos\omega_c t$, the corresponding output will $A + m(t)$. By blocking the dc component A from this output, we can demodulate the AM signal using a DSB-SC demodulator.
The converse, unfortunately, is not true. This is because, when an input to an AM demodulator is $m(t)\cos\omega_c t$, the corresponding output is $|m(t)|$ [the envelope of $m(t)$]. Hence, unless $m(t) \geq 0$ for all t, it is not possible to demodulate DSB-SC signal using an AM demodulator.

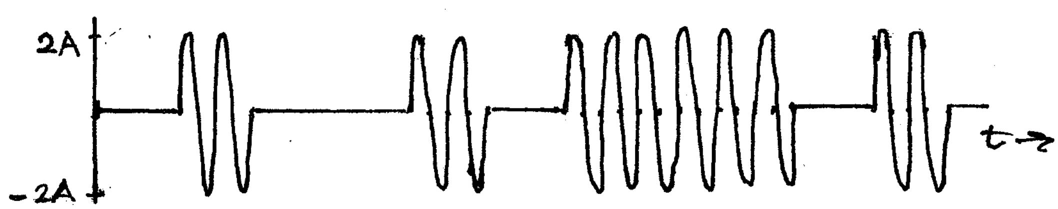

Fig. S4.3-7

4.3-7 Observe that $m^2(t) = A^2$ for all t. Hence, the time average of $m^2(t)$ is also A^2. Thus

$$\widetilde{m^2(t)} = A^2 \qquad P_s = \frac{\widetilde{m^2(t)}}{2} = \frac{A^2}{2}$$

The carrier amplitude is $A = m_p/\mu = m_p = A$. Hence $P_c = A^2/2$. The total power is $P_t = P_c + P_s = A^2$. The power efficiency is

$$\eta = \frac{P_s}{P_t} \times 100 = \frac{A^2/2}{A^2} \times 100 = 0.5$$

The AM signal for $\mu = 1$ is shown in Fig. S4.3-7.

4.3-8 The signal at point a is $[A + m(t)]\cos\omega_c t$. The signal at point b is

$$x(t) = [A + m(t)]^2 \cos^2\omega_c t = \frac{A^2 + 2Am(t) + m^2(t)}{2}(1 + \cos 2\omega_c t)$$

The lowpass filter suppresses the term containing $\cos 2\omega_c t$. Hence, the signal at point c is

$$w(t) = \frac{A^2 + 2Am(t) + m^2(t)}{2} = \frac{A^2}{2}\left[1 + \frac{2m(t)}{A} + \left(\frac{m(t)}{A}\right)^2\right]$$

Usually, $m(t)/A \ll 1$ for most of the time. Only when $m(t)$ is near its peak, this condition is violated. Hence, the output at point d is

$$y(t) \approx \frac{A^2}{2} + Am(t)$$

A blocking capacitor will suppress the dc term $A^2/2$, yielding the output $Am(t)$. From the signal $w(t)$, we see that the distortion component is $m^2(t)/2$.

4.4-1 In Fig. 4.14, when the carrier is $\cos[(\Delta\omega)t + \delta]$ or $\sin[(\Delta\omega)t + \delta]$, we have

$$\begin{aligned} x_1(t) &= 2[m_1(t)\cos\omega_c t + m_2(t)\sin\omega_c t]\cos[(\omega_c + \Delta\omega)t + \delta] \\ &= 2m_1(t)\cos\omega_c t\cos[(\omega_c + \Delta\omega)t + \delta] + 2m_2(t)\sin\omega_c t\cos[(\omega_c + \Delta\omega)t + \delta] \\ &= m_1(t)\{\cos[(\Delta\omega)t + \delta] + \cos[(2\omega_c + \Delta\omega)t + \delta]\} + m_2(t)\{\sin[(2\omega_c + \Delta\omega)t + \delta] - \sin[(\Delta\omega)t + \delta]\} \end{aligned}$$

Similarly

$$x_2(t) = m_1(t)\{\sin[(2\omega_c + \Delta\omega)t + \delta] + \sin[(\Delta\omega)t + \delta]\} + m_2(t)\{\cos[(\Delta\omega)t + \delta] - \cos[(2\omega_c + \Delta\omega)t + \delta]\}$$

After $x_1(t)$ and $x_2(t)$ are passed through lowpass filter, the outputs are

$$m_1'(t) = m_1(t)\cos[(\Delta\omega)t + \delta] - m_2(t)\sin[(\Delta\omega)t + \delta]$$
$$m_2'(t) = m_1(t)\sin[(\Delta\omega)t + \delta] + m_2(t)\cos[(\Delta\omega)t + \delta]$$

4.5-1 To generate a DSB-SC signal from $m(t)$, we multiply $m(t)$ with $\cos\omega_c t$. However, to generate the SSB signals of the same relative magnitude, it is convenient to multiply $m(t)$ with $2\cos\omega_c t$. This also avoids the nuisance of the fractions 1/2, and yields the DSB-SC spectrum $M(\omega - \omega_c) + M(\omega + \omega_c)$. We suppress the USB spectrum (above ω_c and below $-\omega_c$) to obtain the LSB spectrum. Similarly, to obtain the USB spectrum, we suppress the LSB spectrum (between $-\omega_c$ and ω_c) from the DSB-SC spectrum. Figures S4.5-1 a, b and c show the three cases.
(a)From Fig. a, we can express $\varphi_{\text{LSB}}(t) = \cos 900t$ and $\varphi_{\text{USB}}(t) = \cos 1100t$.
(b)From Fig. b, we can express $\varphi_{\text{LSB}}(t) = 2\cos 700t + \cos 900t$ and $\varphi_{\text{USB}}(t) = \cos 1100t + 2\cos 1300t$.
(c)From Fig. c, we can express $\varphi_{\text{LSB}}(t) = \frac{1}{2}[\cos 400t + \cos 600t]$ and $\varphi_{\text{USB}}(t) = \frac{1}{2}[\cos 1400t + \cos 1600t]$.

4.5-2

$$\varphi_{\text{USB}}(t) = m(t)\cos\omega_c t - m_h(t)\sin\omega_c t \qquad \text{and} \qquad \varphi_{\text{LSB}}(t) = m(t)\cos\omega_c t + m_h(t)\sin\omega_c t$$

(a) $m(t) = \cos 100t$ and $m_h(t) = \sin 100t$. Hence,

$$\varphi_{\text{LSB}}(t) = \cos 100t\cos 1000t + \sin 100t\sin 1000t = \cos(1000 - 100)t = \cos 900t$$

$$\varphi_{\text{USB}}(t) = \cos 100t\cos 1000t - \sin 100t\sin 1000t = \cos(1000 + 100)t = \cos 1100t$$

(b) $m(t) = \cos 100t + 2\cos 300t$ and $m_h(t) = \sin 100t + 2\sin 300t$. Hence,

$$\varphi_{\text{LSB}}(t) = (\cos 100t + 2\cos 300t)\cos 1000t + (\sin 100t + 2\sin 300t)\sin 1000t = \cos 900t + 2\cos 700t$$

$$\varphi_{\text{USB}}(t) = (\cos 100t + 2\cos 300t)\cos 1000t - (\sin 100t + 2\sin 300t)\sin 1000t = \cos 1100t + 2\cos 1300t$$

(c) $m(t) = \cos 100t\cos 500t = 0.5\cos 400t + 0.5\cos 600t$ and $m_h(t) = 0.5\sin 400t + 0.5\sin 600t$. Hence,

$$\varphi_{\text{LSB}}(t) = (0.5\cos 400t + 0.5\cos 600t)\cos 1000t + (0.5\sin 400t + 0.5\sin 600t)\sin 1000t = 0.5\cos 400t + 0.5\cos 600t$$

$$\varphi_{\text{USB}}(t) = (0.5\cos 400t + 0.5\cos 600t)\cos 1000t - (0.5\sin 400t + 0.5\sin 600t)\sin 1000t = 0.5\cos 1400t + 0.5\cos 1600t$$

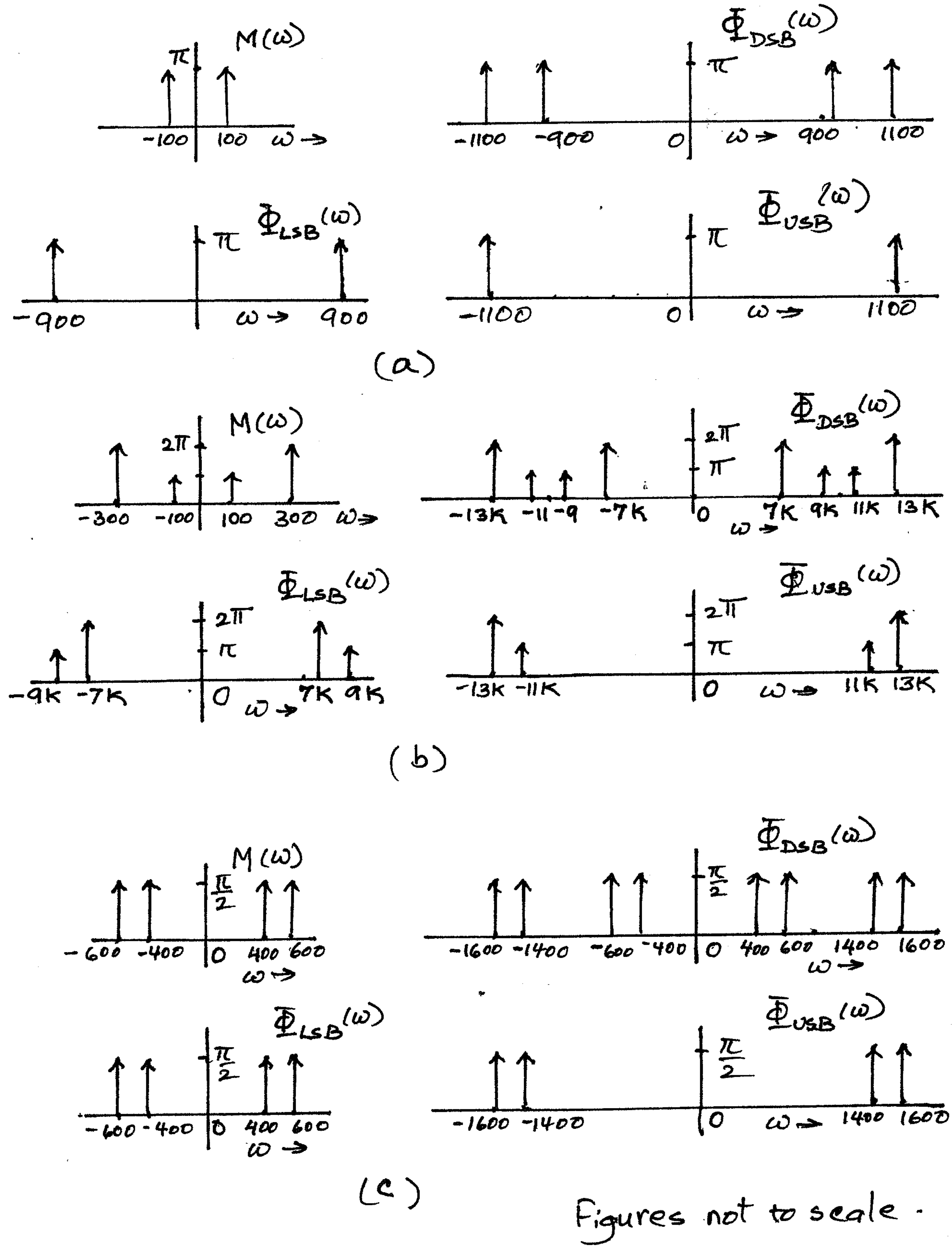
M(ω)
Φ_DSB(ω)
Φ_LSB(ω)
Φ_USB(ω)
π
2π
π/2
ω →
-100 100
-1100 -900 0 900 1100
-900 900
-1100 0 1100
(a)
-300 -100 100 300
-13K -11 -9 -7K 0 7K 9K 11K 13K
-9K -7K 0 7K 9K
-13K -11K 0 11K 13K
(b)
-600 -400 0 400 600
-1600 -1400 -600 -400 0 400 600 1400 1600
-1600 -1400 0 1400 1600
(c)
Figures not to scale.

Fig. S4.5-1